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WYOMING UNIVERSITY
LARAMIE

1 APRIL 1977

DEPARTMENT OF PHYSICS & ASTRONOMY

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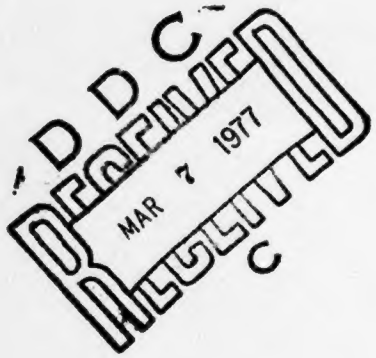

Annual Report on Contract #
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Submitted by

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ABSTRACT

Measurement of condensation nuclei (CN) in the size range $r \geq 0.01\mu m$ by balloon-borne detectors from a number of stations suggests the following:

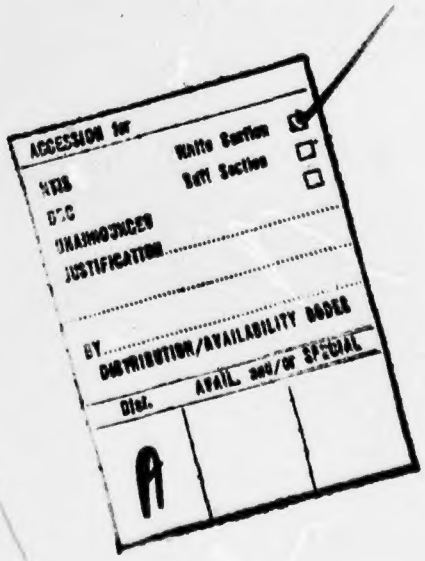
a) CN profiles (concentration vs altitude) to 30km are somewhat uniform globally with typically high ($\sim 10^3 cm^{-3}$) concentrations in the troposphere and typically low ($\sim 10\ cm^{-3}$) concentrations in the stratosphere.

b) The troposphere appears to serve as a CN source for the stratosphere.

c) CN occuring in tropospheric layers are partially volatile at 150°C.

d) A CN layer observed in the stratosphere at 22km was apparently due to the jet engine emissions of a high flying aircraft.

In addition, larger particles ($r \geq 0.15\mu m$) in the stratospheric sulfate layer have continued to decay uniformly following an injection apparently due to a volcanic eruption in October, 1974.



Introduction

This report constitutes the annual report on ONR contract #N00014-76-C-0170. Our main goal is to determine the source of atmospheric condensation nuclei (CN), the small particle portion of the atmospheric particle size distribution, and to assess the effects of jet aircraft on this particle distribution. In addition, regular measurements of the large sulfate aerosol particles have continued in an effort to assess the source and sink strengths of these particles which are important in the radiative energy balance of the atmosphere.

Research Activities

Table 1 lists balloon soundings conducted since the last report (Data report AP-37, September, 1976). The first three flights, conducted in September, 1976, constituted a concerted effort to compare different techniques of measuring CN. Each flight included three CN detectors. An expansion chamber/photographic detector unit, provided by K. H. Käselau of the University of Cologne, Federal Republic of Germany, was flown along with two of our light scattering CN counters. Each of the latter were operated in different modes in each flight. Results of the German detector are not yet available for comparison. Of particular interest for this project was W-135, in which one of the light scattering CN detectors had its intake tube heated to 150°C throughout the flight, while the other unit operated normally. It was designed to determine the degree of volatility of the particles and thus give information on composition.

At a temperature of 150°C, a typical sulfuric acid aerosol (such as the 20km sulfate particle layer composition) will boil at pressures lower than about 300 mb. If any of the CN are due to aircraft, one would expect at least some

of them to contain carbon which would not boil at this temperature. The method is not without some uncertainties, however. For example, if a particle apparently boils away at 150°, we cannot be sure that it didn't contain a core or nucleus which was non-volatile and smaller than our lowest detectable size range (r~0.01μm), i.e. it is possible that only the outer layers of volatile material, which could build up under normal particle growth processes, had boiled away. Another difficulty lies in the fact that some representative natural atmospheric aerosol materials have boiling points higher than 150°, for example, ammonium sulfate. Thus, non-volatility at 150° would not ascertain that the particles contained carbon.

Our approach to the problem has been to start at the bottom and work up, i.e. beginning at a temperature of 150°, we can study the importance of sulfuric acid in the CN. The next step is to increase the temperature to study other possible constituents.

Figure 1 shows the results of the 150° boiling experiments conducted at Laramie in September, 1976. Both the heated and normal CN concentration profiles are given. Although the two profiles agree well in general terms, it is apparent that nearly half of those particles contained in definite layers are volatile at 150°. In the tropospheric layers (below ~13km), where the humidity may be sufficiently high, many of the particles may contain enough water to boil below our detection size threshold. One would not expect this to occur in the drier stratosphere, however, and we must conclude that most of the stratospheric CN have boiling points above 150°C, in contrast to the stratospheric sulfate layer (larger particles).

The conspicuous stratospheric layer at 22 km merits special attention. In some ten previous CN soundings, no high altitude layers of this nature had been observed. We must thus regard it as a highly transient phenomenon. The

data in Figure 1 were obtained on balloon ascent and the layer was again observed on parachute descent about an hour later at a location about 10km distant from the point of ascent penetration.

We have surmised that the layer was due to a high flying aircraft, probably of a military reconnaissance type, and have requested further information through the Office of Naval Research. Information on the flight path of the aircraft through the Laramie area and data on fuel expenditure and flight frequency are necessary in order to further analyze the event. Such data would allow estimation of diffusion parameters and the strength of this stratospheric CN source. The rarity of observation of such layers suggests that such aircraft flights are probably negligible CN sources in comparison to such phenomena as diffusion from the troposphere and meteorite vaporization.

In continuing our research effort to determine the sources of CN, we plan to conduct a sounding with an intake heated to 250°C. At this temperature ammonium sulfate, another probable aerosol constituent, would boil away. In this manner we hope to eventually determine the degree of truly non-volatile aerosol, at least for sizes above 0.01μm.

In addition to the aforementioned research, we have continued monthly measurements of the $r \geq 0.15\mu m$ stratospheric sulfate layer which has now decayed to a concentration of about 1 cm^{-3} from a high of about 8 cm^{-3} in early 1975, shortly after the eruption of the volcano Fuego in Guatemala. This rather long period (~30 months) without any apparent large volcanic eruptions has allowed us to study the decay of such injections which appear to have an exponential decay with a e^{-1} time of about 1 year for particles having $r \geq 0.15\mu m$. Of particular interest here is if the concentration ever reaches a true "background" due to anthropogenic sources. Prior to the eruption of Fuego, the concentration had reached a low of about 0.5 cm^{-3} and should again reach this value by late

1977 barring any new volcanic injections.

In January, 1977 we conducted the first CN soundings at the South Pole and in Australia. Preliminary results indicate profiles similar to that observed at previous sites, i.e. high concentrations in the troposphere and low concentrations in the stratosphere. The South Pole tropospheric concentrations were observed to be unusually high (~10^3 from ice level to the tropopause); i.e. considerably higher than the typical 50-100 cm^{-3} observed at ice level in the past. This may have been an unusual day, affected by transport from other regions or it may be a typical situation wherein concentrations may be low near the surface but high throughout the rest of the troposphere. On occasion, surface measurements have indicated increases to be as high as 1500 cm^{-3} which may be a manisfestation of these high troposhperic concentrations. Obviously, further measurements are necessary to properly study this phenomenon.

TABLE 1

Flt. #	Location	Date	Constituents Measured
W-135	Laramie	18 Sept. 1976	CN(2), T
W-136	Laramie	22 Sept. 1976	CN(2), T
W-137	Laramie	25 Sept. 1976	CN(2), T
W-138	Laramie	30 Sept. 1976	A, CN(2), T
W-139	Laramie	2 Nov. 1976	A, T
W-140	Laramie	2 Dec. 1976	A, T
W-141	Laramie	30 Dec. 1976	A, T
W-142	Laramie	17 Feb. 1976	A, T
A-25	McMurdo	15 Jan. 1977	A, T
A-26	South Pole	18 Jan. 1977	O, T
A-27	South Pole	19 Jan. 1977	CN, T
M-17	Mildura	3 Feb. 1977	CN, T
W-142	Laramie	17 Feb. 1977	A, T

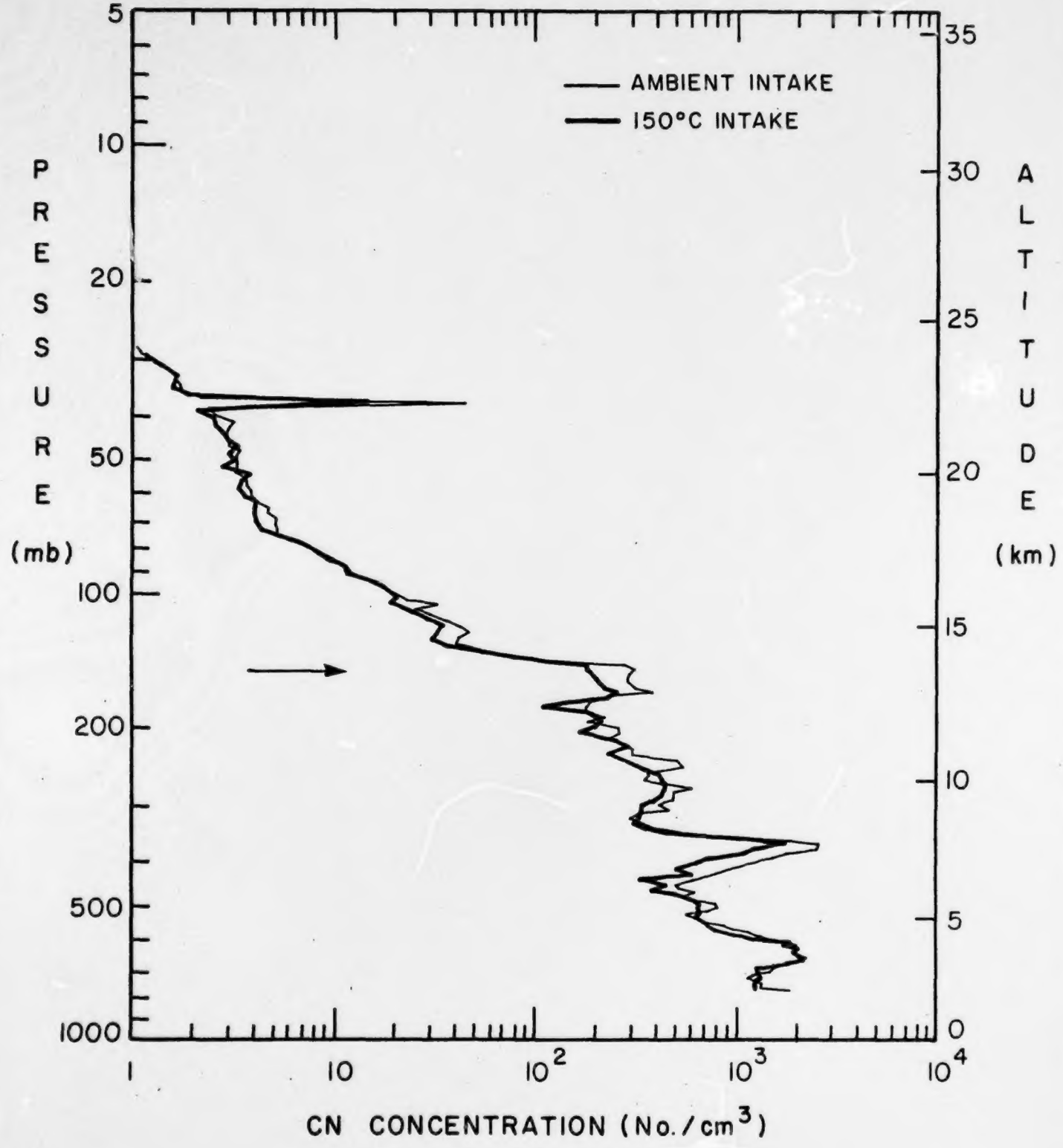
A - Aerosol ($r \geq 0.15\mu m$)

CN - Condensation Nuclei ($r \geq 0.01\mu m$)

T - Temperature

O - Ozone

Figure 1. Condensation nuclei profiles measured over Laramie on 18 September 1976. The arrow marks the observed position of the tropopause.


AMBIENT INTAKE
150°C INTAKE
PRESSURE (mb)
ALTITUDE (km)
5
10
20
50
100
200
500
1000
35
30
25
20
15
10
5
0
1
10
10^2
10^3
10^4
CN CONCENTRATION (No./cm^3)